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# Climate, Ocean and Sea Ice Modeling (COSIM)

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## Summary

The COSIM project develops advanced ocean and ice models for evaluating the role of ocean and ice in high-latitude climate change and projecting the impacts of high-latitude change on regions throughout the globe.

COSIM researchers develop, test and apply ocean and ice models in support of DOE Climate Change Research and the broader international climate science community.

Additional research includes developing a set of next-generation ocean and ice models with variable resolution horizontal grids to focus resolution on regions of interest or regions where specific processes (like eddies) need to be resolved.

## Capabilities

- climate modeling
- high-performance computing
- oceanography
- ocean biogeochemistry
- sea ice
- ice sheets
- sea level rise

## Project Description

Over the past 15 years, Los Alamos has developed a strong program in numerical modeling of the oceans and sea ice, with special emphasis on high-performance computing...

We continue to develop the necessary models and software tools for addressing the important science areas below. In particular, we:

- Develop, validate and optimize the Parallel Ocean Program (POP), including improvements in the formulation of the model equations, parameterizations of physical processes, numerical methods, and portability and performance optimization on a range of computer architectures.
- Develop, validate and optimize the Los Alamos sea ice model (CICE), including the efficient and accurate solution of the ice dynamics equations, improvements in the

sea ice thermodynamics and thickness distribution and implementation of new or improved parameterizations.

- Develop ice sheet models, with a focus on improved numerical methods and coupled climate applications.
- Add biogeochemical processes to ocean and ice models, including trace gases like dimethyl sulfide (DMS) as well as methane and other parts of the carbon cycle.

We are also developing a set of next-generation ocean and ice models with variable resolution horizontal grids to focus resolution on regions of interest or regions where specific processes (like eddies) need to be resolved.

We apply our models to a number of scientific issues related to climate change, including:

- Sea Level Rise: The rate of sea level rise is one of the largest unknowns in current climate models and requires our advanced ocean and ice sheet models for accurate future projections.
- Rapid changes in the Arctic, especially the factors governing the recent rapid decreases in Arctic sea ice and the impacts of an ice-free Arctic on the global climate.
- The role of ocean mesoscale eddies on the global circulation of the ocean.
- High latitude biogeochemical interactions that include the potential for methane release as well as the specialized ecosystems within the ice and at the ice-ocean interface.

#### Technologies and Applications: Emerging, Developed, or Potential

Our next-generation ocean and ice models will utilize variable resolution meshes that allow us to apply our models in specific regions of interest (e.g. the Arctic) and also provide a more efficient means of resolving particular features of the ocean circulation or ice sheet changes...

For example, ice sheet melting occurs most strongly around the margins of the ice sheet and where ice shelves extend out over the ocean, so being able to focus resolution on these regions will provide more accurate simulations at lower cost than uniform models.

We continue to develop new algorithms and new techniques for improving model performance on advanced computation architectures.

As the computing trends move toward large multi-core nodes and accelerated (eg GPU) architectures, our models must evolve to best make use of the underlying hardware.

#### Related Work

While the COSIM project is focused on global modeling for climate change, a number of other LANL projects include field work like the ecosystem experiments by Nate McDowell and the deployment of atmospheric observational instruments (DOE-ARM).

#### Key Personnel

- Phil Jones
- Matthew Hecht
- Elizabeth Hunke
- Mat Maltrud
- Bill Lipscomb

- Scott Elliott
- Todd Ringler
- and several more...

#### Sponsors, Funding Sources, or Agencies

- DOE Office of Science (mostly) DOE Fossil Energy LDRD

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